Smoking Out Worms

Nightcrawlers may be at least partly responsible for the sometimes rapid movement of liquid animal manure and chemicals such as fertilizer nutrients and pesticides through soil to underground drainage pipes.

Farmers with large livestock feedlots need to recycle voluminous quantities of manure by applying it to their fields as fertilizer. Often they store it in special ponds as a liquid slurry. To reduce odor and nutrient losses, farmers generally use special equipment to inject the liquid manure under the soil surface, rather than just spray it on top of fields.

But in Ohio at least, USDA's Natural Resources Conservation Service (NRCS) and the Ohio Department of Natural Resources receive complaints each year about animal wastes turning up in water pouring out of drainage pipes—often called "tiles," from the days when they were made of ceramic—at the edges of fields and in nearby streams, shortly after manure injection into the fields.

Soil scientist Martin J. Shipitalo, at the ARS North Appalachian Experimental Watershed Laboratory in Coshocton, Ohio, and Frank Gibbs, with NRCS in Findlay, Ohio, studied pipe-drained no-till fields with liquid manure applications. "We wanted to see what role wormholes might play in funneling manure to below-ground pipes quickly, before it can be held by the soil and used by plants," Shipitalo says.

No-till fields in poorly drained areas of the United States, such as northwestern Ohio—and fertilized with liquid manure—are especially conducive to worms. Nightcrawlers *(Lumbricus terrestris)* especially like the combination of no-till, drainage pipes, and manure. No-till involves no plowing before planting, so it leaves leftover parts of previous crops on the surface. This provides food for the worms, as does the manure.

The crop residue also offers shelter for worms and helps increase their populations. It also keeps wormholes intact, since there's no plowing to break them up. And the drainage pipes aerate the soil nicely—especially the soil used to cover the pipes. The plastic pipes have drainage holes, the same as the pipe used by homeowners to funnel rainwater away from their homes.

Nightcrawlers Go Deeper

These types of fields tend to have higher than usual numbers of nightcrawlers and other worms, which congregate close to pipes, Shipitalo says. "Unfortunately for drainage problems, nightcrawlers dig deeper and wider holes, or burrows, than many other earthworms do. These holes can become a shortcut for conducting pesticides or manure or surplus fertilizers to groundwater or streams. Normally, soil acts as a filter for potential pollutants if they stay in the soil long enough for microbes to break them down or—in the case of fertilizers—for plants to use them," Shipitalo says.

JENNIFER SMELTZER (D209-1)

To see whether wormholes funnel manure to drain pipes, ARS scientists trace wormhole connections to pipes by blowing smoke through pipes and watching it pour out of surface wormholes.

PEGGY GREB (D182-42)

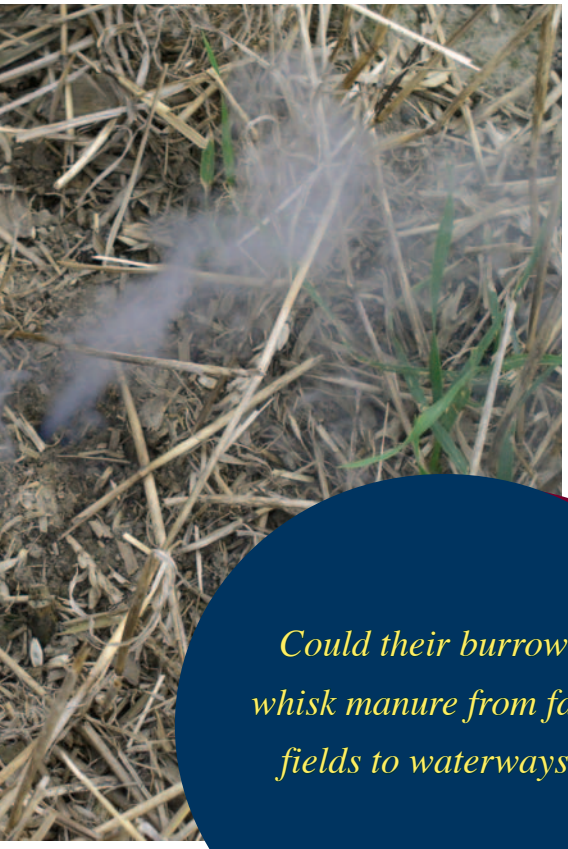
After pouring plastic resin into the hole of an earthworm and excavating the soil around the mold that formed, soil scientist Martin Shipitalo observes the plastic replica of the worm's burrow.

Down the Drain

Underground draining of fields is a common practice in parts of the country where natural drainage is poor. It's increasing in popularity, with pipes now being buried shallower and closer together.

Shipitalo and Gibbs traced wormhole connections to drainage pipes by blowing smoke through the pipes and watching for it to pour out of nearby surface wormhole entrances. "In a study of 38 nightcrawler burrows, we found that the burrows tended to drain into the pipes when they were within 2 feet of a tile line," Shipitalo says.

"To test how fast manure-laden water could move through the burrows to the



Could their burrowing whisk manure from farm fields to waterways?

tiles, we used a brilliant blue dye and a fluorescent dye. We poured the blue water into the burrows that had emitted smoke and the fluorescent dye in the other burrows," Shipitalo says.

On average, the researchers found that water moved through the burrows that were within 2 feet of the pipes—and had emitted smoke—twice as fast as through the other worm burrows. Having the pipes as drainage outlets helped drain the burrows quickly, showing they could move manure quickly as well. Injecting liquid manure under pressure may further increase its flow rate into drainpipes through worm holes.

Often such rapid leaching is via cracks in the soil or bedrock, through which polluted water flows, but there were no visible cracks in the fields studied. Another possible cause of waste drainage is overapplying liquid manure. But this was not the case in the Ohio experiments, in which the scientists were careful to apply only as much liquid manure as the soil could hold without becoming saturated.

Earthworm burrows can have a greater effect than soil cracks on chemical and manure movement because the burrows tend to stay open year round, while soil cracks tend to close up when the soil gets wet.

The scientists also filled the wormholes with a plastic resin to create molds of them. They studied the molds to see whether wormhole geometry had anything to do with speeding the flow of water to the pipes. It didn't. But they were able to predict waterflow speed based on the holes' proximity to the pipes.

Shut It Off!

One possible solution would be to avoid injecting liquid manure within 2 feet of a drainage pipe, if pipe locations are known. Another possibility would be to break up wormholes by tilling the surface above each pipe before applying manure.

"The most practical and best suggestion, though," Shipitalo says, "would be to install shutoff valves so the drains can be shut during manure application and for a short time afterwards. Ohio farmers are currently doing this, with cost-sharing from the Ohio Department of Natural Resources.

"Catch basins could be another answer," he continues. "These pits would collect water draining from the pipes at the field edges and capture it for reuse. These techniques would help whether the manure was leaking through wormholes, soil cracks, or other openings."—By **Don Comis,** ARS.

PEGGY GREB (D181-24)

Soil scientist Martin Shipitalo (right), assisted by NRCS resource soil scientist Frank Gibbs, uses a funnel inserted into the opening of an earthworm burrow and a Mariotte device to measure water infiltration rate in an individual earthworm burrow.

This research is part of Water Quality and Management, an ARS National Program (#201) described on the World Wide Web at www.nps.ars.usda.gov.

Martin J. Shipitalo is with the USDA-ARS North Appalachian Experimental Watershed Laboratory, P.O. Box 488, Coshocton, OH 43812-0488; phone (740) 545-6349, ext. 212, fax (740) 545-5125, e-mail martin@coshocton.ars.usda.gov.

Frank Gibbs is with the USDA-Natural Resources Conservation Service, 7868 County Road 140, Suite F, Findlay, OH 45840; phone (419) 422-5438, ext. 139, fax (419) 425-4147, e-mail frank.gibbs@oh.usda.gov. ✸